Imperial County (Calif.)

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seismic and public safety element

1993

SEISMIC AND PUBLIC SAFETY ELEMENT
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I. INTRODUCTION

A. Preface

The County of Imperial is exposed to a wide variety of hazards that result from natural phenomena and human-induced accidents. These hazards can result in loss of life, bodily injury, and property damage. The County is bisected by active seismic faults that could generate dangerous earthquakes and other geologic activity. Although the County is located in a desert with very low precipitation, it is sometimes subject to heavy rains and subsequent flooding. Flooding could also result from damage to the All American Canal and associated transmission aqueducts. A few hazardous waste facilities are located in the County and accidents could dangerously pollute air and water.

The Seismic and Public Safety Element identifies potential natural and human-induced hazards and provides policy to avoid or minimize the risk associated with hazards. Potential hazards must be addressed in the land use planning process to avoid the unfolding of dangerous situations. For example, the risk associated with dangerous flooding can be avoided by not allowing development in floodplains and imposing strict safety standards on water transmission facilities.

A Safety Element is a mandatory element of the General Plan according to California Government Code Section 65302. This Seismic and Public Safety Element has been prepared to conform to the following requirement of the Government Code:

> A safety element for the protection of the community from any unreasonable risks associated with the effects of seismically induced surface rupture, ground shaking, ground failure, tsunami, seiche, and dam failure; slope instability leading to mudslides and landslides, subsidence and other geologic hazards known to the legislative body; flooding; and wildland and urban fires. The safety element shall include mapping of known seismic and other geologic hazards. It shall also address evacuation routes, peakload water supply requirements, and minimum road widths and clearances around structures, as those items relate to identified fire and geologic hazards.

B. Purpose of the Seismic and Public Safety Element

The purpose of the Seismic and Public Safety Element is directly concerned with reducing the loss of life, injury, and property damage that might result from a disaster or accident. This Element identifies goals and policies that will minimize the risks associated with natural and human-made hazards. In addition, the Element specifies land use planning procedures that should be implemented to avoid hazardous situations.

C. Risk Assessment

Risk assessment refers to the subjective process of comparing the cost to avoid or reduce a hazard with the cost of the potential damage produced by the hazard. The concepts "acceptable risk" and "avoidable risk" are important in risk assessment. An avoidable risk refers to situations where the risk of a potential hazard can be entirely reduced by circumventing the development of the potential hazard. An example of an avoidable risk is the preclusion of residential development in floodplains. Avoiding the risk, however, can involve costs which are measured by time, money, inconvenience, and inefficiency. Under these circumstances, the reduction in risk must be weighed against costs. An acceptable risk refers to the point where an incremental reduction in risk does not justify increased cost. An example of an acceptable risk is the development of a gravel mining operation in a floodplain that possesses large gravel reserves. While there is a risk of flooding, locating a gravel mining operation outside of the floodplain would be inefficient and economically infeasible.

In establishing guidelines for acceptable risk, the County makes distinctions between hazards resulting in personal injury or loss of life, hazards resulting in disruption of essential services, and hazards resulting in damage to structures and property. The risks of personal injury, loss of life, and the disruption of lifelines are unacceptable but the risk of structural damage is acceptable. The County will impose restrictions or conditions on development to avoid personal injury, loss of life, and lifeline disruption and reduce the threat of structural damage.

II. EXISTING CONDITIONS AND TRENDS

A. Geologic Activity

Earthquakes are the principal geologic activity affecting public safety in Imperial County. They are a triggering event which permit the force of gravity to operate and create many secondary hazards from ground shaking, including: (1) differential ground settlement, soil liquefaction, rock and mudslides, ground lurching, and avalanches; (2) ground displacement along the fault; (3) floods from dam and levee failure, and seiches; (4) fires; and (5) the various adverse results of disruption of essential facilities and systems - water, sewer, gas, electricity, transportation, and communication (and notably in Imperial Valley, the irrigation and drainage system). This section will focus on earthquakes and other geologic activities; flooding, fires, and disruption of essential services, whether seismically induced or otherwise, will be discussed separately.

1. Earthquakes

Earthquakes, are the result of an abrupt release of energy stored in the earth. This energy is generated from the forces which cause the continents to change their relative position on the earth's surface, a process called "plate tectonics." The earth's outer shell is composed of a number of relatively rigid plates which move slowly over the comparatively fluid molten layer below. The boundaries between plates are where the more active geologic processes take place. Earthquakes are an incidental product of these processes.

California rests on the boundary between the North American Plate and the Pacific Plate. The San Andreas Fault system is located where the northwesterly drifting Pacific Plate grinds along and is subducted by the southwesterly drifting North American Plate. Baja, and California west of the fault system, are part of the Pacific Plate and move northwest compared to the rest of California and North America.

The Imperial Valley is a broad, flat, alluviated area that lies partly below sea level, cut off from the Gulf of California to the south by the Colorado River Delta. The valley, also known as the Salton Trough, is one of the most tectonically active regions in the United States. The eastern boundary is formed by branches of the San Andreas fault and the western boundary is formed by the San Jacinto-Coyote Creek and the Elsinore-Laguna Salada Faults. Consequently, the Valley is subject to potentially destructive and devastating earthquakes. Figure 1 shows the general location of known or inferred major fault lines in Imperial County.

More small to moderate earthquakes have occurred in the Imperial Valley area than along any other section of the San Andreas Fault system. During the current century, the areas has experienced eleven earthquakes of magnitude 6.0 or greater on the Richter scale with the strongest being a magnitude of 7.1 on the Imperial Fault in 1940. The deep, sediment-filled

Imperial County General Plan

Seismic Activity in Imperial County

Seismic and Public Safety Element

Figure 1

geologic structure of the Imperial Valley makes the area particularly susceptible to severe earthquake damage. The Cities of Brawley, Imperial, El Centro, and Calexico have experienced damage from the movements of major faults in the San Jacinto fault zone, which includes the Imperial and Superstition Hills Faults.

A moderate to severe incident with intense ground shaking in the populated areas of Imperial County could reasonably be expected to cause numerous casualties, extensive property damage, fire, road closures, disruption of rail systems, communication systems (particularly telephone systems), the County's extensive canal system, and utilities. In addition, health hazards would be posed by damaged sewer systems, waste treatment facilities, and the possible contamination of the County's potable water supply. Medical treatment facilities would most likely be overtaxed. Theft and looting may also be a problem. The resultant disruption of the agricultural community would affect the local economy.

In accordance with the Alquist - Priolo Special Studies Zone Act (Chapter 7.5, Division 2, Public Resources Code, State of California, effective May 4, 1975) the Office of State Geologist delineated Special Study Zones which encompass potentially and recently active traces of four major faults (San Andreas, Calaveras, Hayward and San Jacinto). These Special Study Zone Maps depicting active fault traces are available for public review at the Imperial County Planning Department and the Imperial County Public Works Department. The Alquist - Priolo Special Study Zone Act is enforced by the County to assure that homes, offices, hospitals, public buildings, and other structures for human occupancy which are built on or near active faults, or if built within special study areas, are designed and constructed in compliance with the County of Imperial Codified Ordinance.

It is difficult to predict the severity of casualties and property damage that could result from an earthquake. The severity of casualties and property damage depend on the intensity of the earthquake, location of the epicenter to populated areas, and the time of day of the occurrence. The analysis of past earthquakes provides some useful information regarding the potential consequences of future severe earthquakes. Appendix A provides a summary of earthquakes that have impacted the County between 1852 and 1988.

The 1940 earthquake along the Imperial Fault registered a 7.1 on the Richter scale. The epicenter was located east of El Centro. The ground was ruptured for forty miles from Volcano Lake in Baja California to a point near the City of Imperial. Seven deaths occurred and property loss was in excess of $5 million. Eighty percent of the buildings in Imperial were destroyed; fifty percent of Brawley's structures were damaged. Indirect damage to crops was substantial due to the subsequent disruption of drainage and flooding. Horizontal displacement across the completed but unfilled International Canal was 14 feet, 10 inches and the U.S.-Mexico boundary was permanently changed. The Alamo Canal in Baja California was also offset and a local flood resulted from water spilling out of the broken channel.

Perhaps the most conspicuous area of surface rupture was on State Highway 98 eight miles east of Calexico. The roadway was broken by a four-foot scarp, and rows of trees in an orange grove south of the highway and west of the Alamo River bridge were offset almost 10 feet. The maximum horizontal displacements of the earthquake, which were approximately 29 feet, were measured in the area just south of the orange grove.

Existing information about earthquakes that have occurred in Imperial Valley suggest that an equal number of earthquakes of equal intensity may occur within the future. The County can expect injuries, casualties and property damage from earthquakes as some time in the future because of the past frequency of moderately high magnitude and intensity earthquakes; the distribution of active faults and epicenters; and the projected increase in population.

2. Landslides

A landslide refers to slowly to very rapidly descending rock or debris caused by the pull of gravity. Landslides affect humans in many ways. A very rapid landslide could result in casualties and devastating property damage while a slow landslide could result in the nuisance of having a fence slowly pulled apart. The cost in lives and property from landslides is surprisingly high. According to the U.S. Geological Survey, more people in the United States died from landslides during the last three months of 1985 than were killed by all other geologic hazards, such as earthquakes and volcanic eruptions. The damage to property from landslides each year exceeds the cost of earthquake damage for the last twenty years.

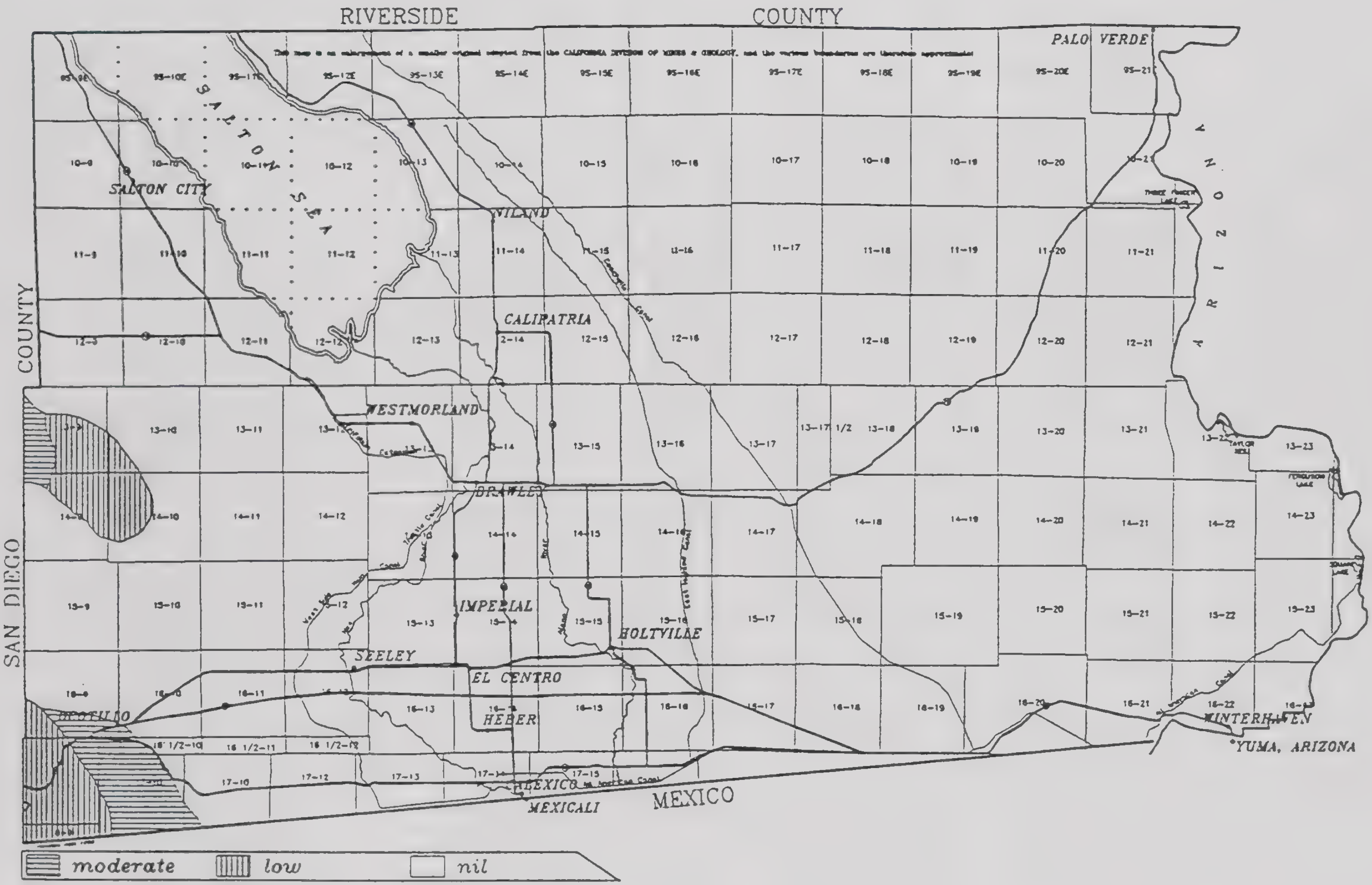
The process of grading can accelerate landslide activity. Slope and material failure often results from failing to utilize precautionary measures to stabilize slopes or cutting into the failure plane of an existing landslide. In California, landslides are a common problem in the hillside areas and particularly in developed hillside areas that required grading.

The potential for landslides in Imperial County is low to moderate along the western edge of the County parallel to the Coast Range Mountains. Additional areas in the County subject to landslides include the irrigated valley between the East Highline and Westside Main canals and bluffs adjacent to the All American Canal, Coachella Canal, New River, Alamo River, and the Colorado River. The hazardous landslide areas adjacent to these water courses are defined as:

1. A distance of fifty feet outside of the shaded flood zone areas delineated on the Federal Emergency Management Agency (FEMA) maps for the New and Alamo Rivers; and

2. A distance of one-half the canal bank height beyond the toe of the slope for all of the levee and canal banks.

Figure 2 illustrates the distribution of landslide activity in the County.



SOURCE: Department of Conservation
Division of Mines and Geology

Imperial County General Plan

Landslide Activity

Figure 2

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3. Subsidence

Subsidence is the gradual, local settling or sinking of the earth's surface with little or no horizontal motion. Subsidence is usually the result of gas, oil, or water extraction, hydrocompaction, or peat oxidation, and not the result of a landslide or slope failure. Ground surface effects related to subsidence are generally restricted to long surface structures such as canals, drains, and sewers, which are sensitive to slight changes in elevation.

Subsidence from earthquakes and other activities, including geothermal resources development, can disrupt drainage systems and cause localized flooding. Agricultural operations within the County depend on gravity-fed irrigation, drainage, and tiling systems. These systems utilize existing land contours and have little tolerance for change. Areas away from the irrigated fields, canals, and drains may be less sensitive to land surface elevation change.

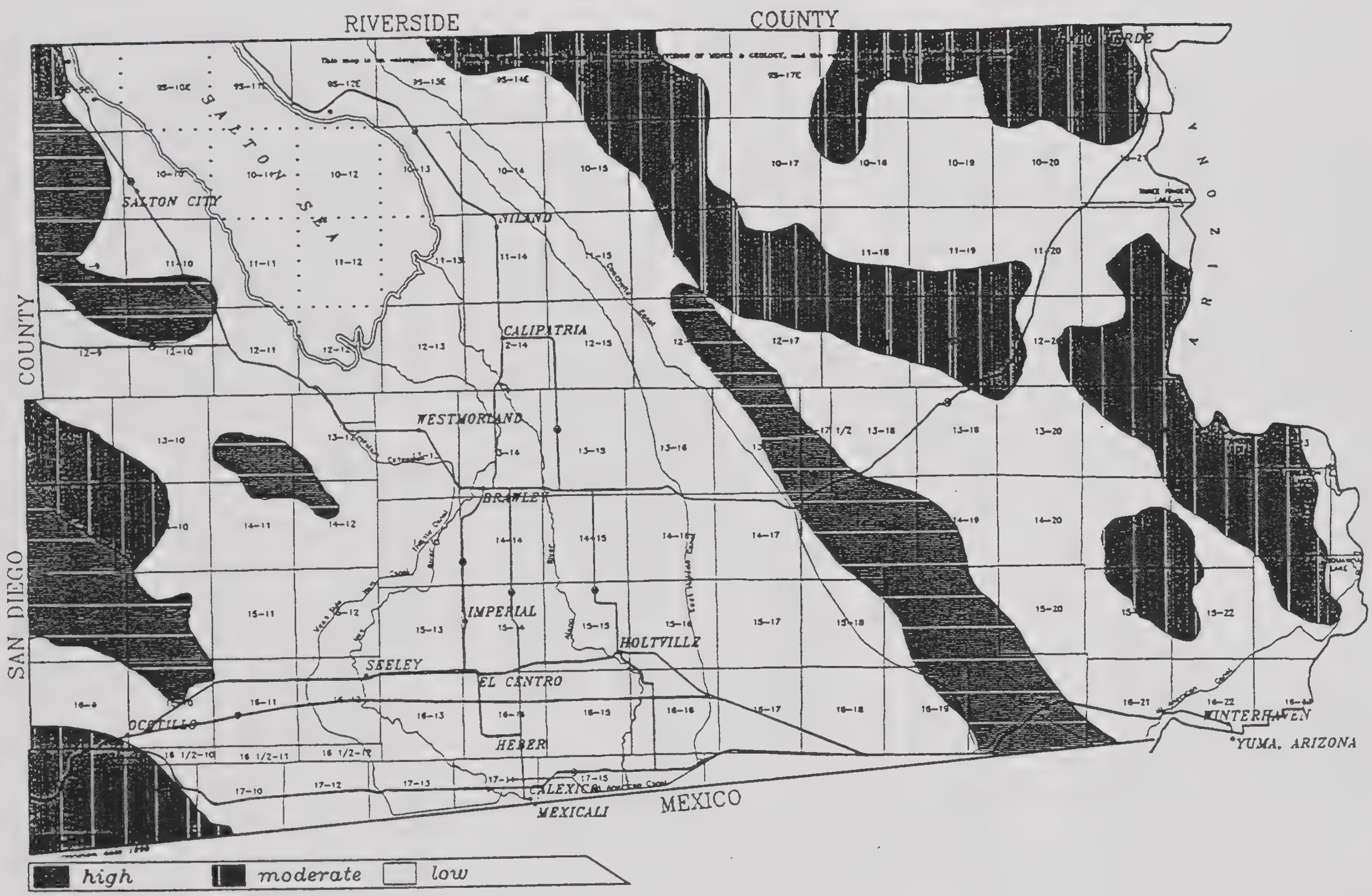
It is also to be noted that the "Valley", within the County, experiences a continuous natural subsidence toward the Salton Sea. Natural subsidence has been occurring within the Salton Trough, averaging nearly two inches per year at the center of the Salton Sea and it decreases to zero near the Mexican border. It is generally uniform, but local depressions have formed such as the Mesquite Sink located along Highway 86 between Imperial and Brawley. Earthquakes have caused abrupt elevation changes in excess of one foot across fault lines.

Increases in development of geothermal resources could be a factor for the future. Recent reports by the geothermal industry in the Heber area indicates that some subsidence has occurred over several years and could be expected to change further depending on the rate and volume of extraction/injection.

Well field programs covering production and injection plans are required by the Bureau of Land Management and the Division of Oil and Gas for each major geothermal project. Detrimental subsidence from geothermal development needs to be avoided through careful permit review by CDOG and the County, establishment of standards for each project, and through impact mitigation and monitoring programs.

4. Erosion

Erosion is the removal of rock fragments or soil by the action of running water, glacial ice, or wind. Human activities can accelerate erosion. The areas in Imperial County that are most subject to erosion are the Algodones Sand Dunes parallelling the East Mesa and Superstition Mountain, and the Chocolate, Picacho, Cargo Muchacho, and Coast Range Mountains. The remainder of Imperial County is generally flat and experiences low levels of natural erosion. Figure 3 illustrates the erosion activity throughout the County.



SOURCE: Department of Conservation
Division of Mines and Geology

Imperial County General Plan

Erosion Activity

Figure 3

5. Soil Stability

The geologically young, unconsolidated sediments of the Salton Trough are subject to failure during earthquakes, especially throughout the irrigation portion of the Valley where the soil is generally saturated. Liquefaction, and related loss of foundation support, is a common hazard.

B. Flooding

Flooding is a natural hazard present in Imperial County due to the County's geography, geology and climate. There are various facets to flooding; all of which are relevant to Imperial County. Flood hazards include the following: natural floodplains, seiches, and dam failure.

1. Natural Floodplains

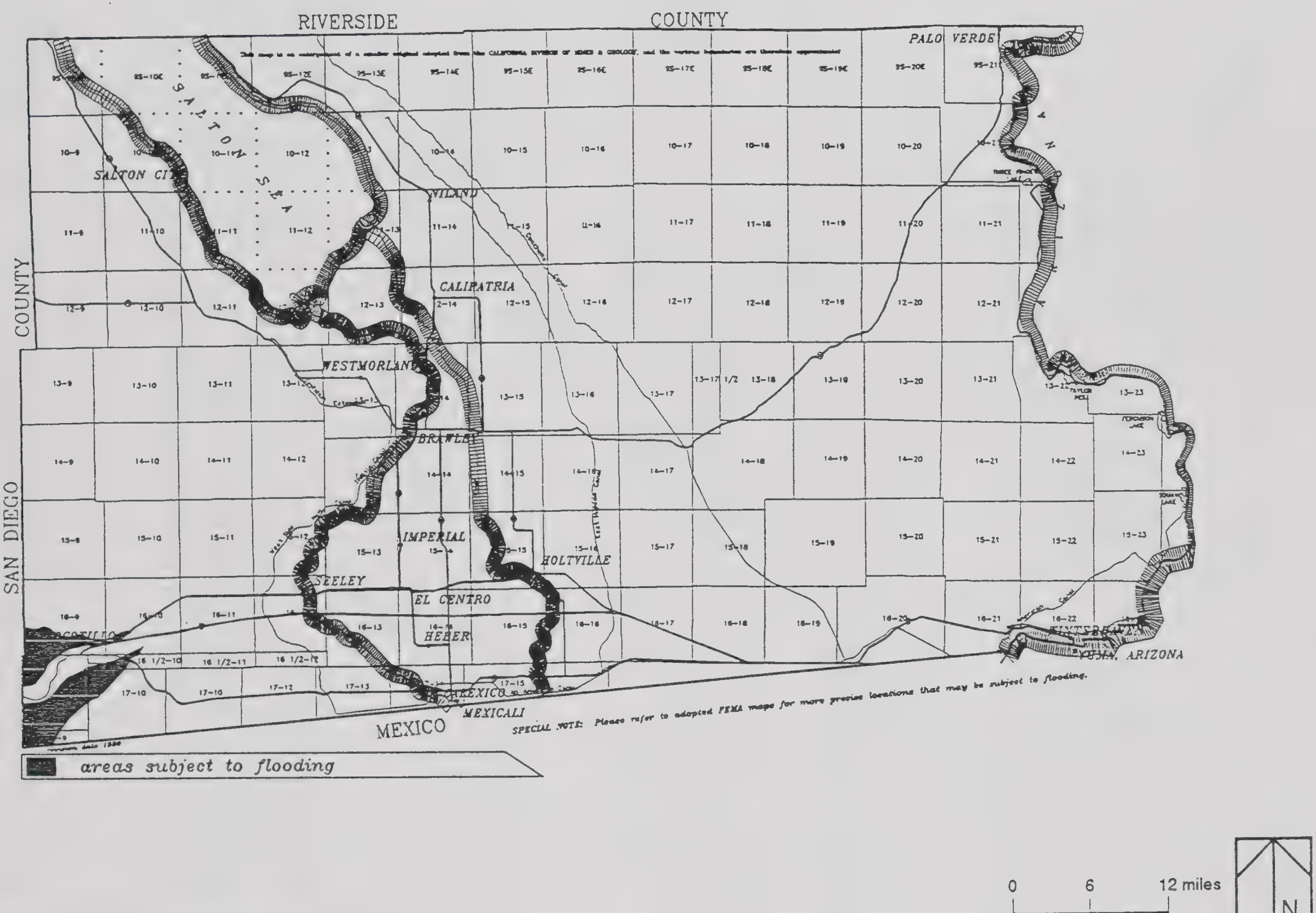
The entire county is subject to various degrees of flooding in the form of flash floods or slow floods caused by heavy precipitation. Flash flooding is not infrequent in desert areas. Such flooding occurs when sudden downpours over the mountains and/or desert tend to create instantaneous peak flows which roughly follow empty stream beds and mountain washes.

Flooding can occur either in floodplains or floodways. Floodplains are generally located adjacent to rivers and other bodies of water, and in low lying areas near a water source. The external boundary of floodplains is defined by the predicted extent of inundation that would result from the most intense storm that occurs once every one hundred years. Floodways are defined by discernible drainage channels. Floodways are more hazardous due to the anticipated velocities of the flood waters and expected damage to life and property. Such designations occur along the Myer Creek (through Ocotillo) and within the levees along the Colorado River. Further information can be obtained by consulting the Flood Insurance Rate Maps (FIRM's) prepared by the Federal Emergency Management Agency, which are on file with the County Department of Planning. Figure 4 illustrates the areas in the County that are particularly at risk to flood hazards.

Within the County jurisdiction, the communities of Bombay Beach and Ocotillo are considered to be the most likely to experience significant flooding. In El Centro, the Gillett/Cannon Roads area receives the heaviest flooding. It is at a low elevation east of El Centro and south of East Evan Hewes Highway.

Bombay Beach is located in a pocket created by the Salton Sea on the west and the Chocolate Mountains on the east. Severe flooding could isolate the community. In the event of a major flood, approximately 300 to 1,000 residents would have to be evacuated.

The communities of Ocotillo and Nomirage are at risk due to their location at the base of an alluvial fan originating at the base of Myer Creek. More specifically, Myer Creek is located in the southwestern part of Imperial County and flows in a northeasterly direction through the townsites of Ocotillo and Nomirage, draining over 21.8 square miles.



SOURCE: Federal Emergency Management Agency

Imperial County General Plan	Flood Areas Seismic and Public Safety Element	Figure 4

Flood plain management is the key component to effective flood control within Imperial County. The Federal Insurance Administration delineates areas of special flood hazards, the risk premium zones, and floodways through official maps: Flood Insurance Rate Map (F.I.R.M.); and Flood Boundary and Floodway Map. These maps form the basis for Imperial County's Flood Ordinance which is intended to be applied to those areas which are subject to periodic flooding and accompanying hazards. These official maps show all canals, drains, and rivers, and at 1"-1000' are a useful reference map. Most of the irrigated valley is designated zone "C" - indefinite minor flooding - reflecting the flat terrain and the canal system. Official Flood Insurance Rate Maps (F.I.R.M.) are available for public use at the Planning Department of Imperial County.

2. Seiches

A seiche is a to and from vibration of a body of water like the slopping of water in a jolted basin. Once initiated, the water body continues to oscillate independently. Seiches can be triggered by seismic events such as earthquakes.

The most likely location for a significant seiche to occur is the Salton Sea. While there have been a number of seismic events since the formation of the Salton Sea, no significant seiches have occurred to date. A seiche could occur, however, in the Salton Sea under the appropriate seismic conditions. The Salton Sea is proximal to the San Andreas and San Jacinto faults and would be subject to significant seismic ground shaking that could generate a seiche.

3. Dam Failure

Flooding, due to dam failure, is a factor which could seriously affect eastern Imperial County. The California Office of Emergency Services is charged with keeping on file the "inundation map" and "dam failure response plan" for each dam in the state. The dam owner/operator is, however, responsible for map and plan preparation. These documents generally do not exist. Imperial Dam, the only significant dam in Imperial County, has a plan, but no map; Laguna Dam has no plan, but the map is under preparation; Senator Wash Dam has no plan or map; and the Parker Dam has a plan, but no map. Failure of any of these dams would certainly cause inundation of the down stream shorelines, all of the Bard - Winterhaven area, and possibly would flush large quantities of water through Mexico into the New and Alamo Rivers. Inundation of the community, however, is considered unlikely; hazard analysis suggests that dam failure would likely occur only if heavy precipitation was coupled with significant seismic activity near the dam. Flooding through Mexico would most probably be confined to the already designated flood areas.

C. Fire

The potential for a major fire in the unincorporated areas of the County is generally low. Fire hazards exist, however, at two different sites in the County at the fuel storage farms located south of the City of Imperial and east of Niland. In the event of a fire, assistance from various

fire departments within the County would be required. The threat of fire spreading and causing major problems to other areas of the County are minimal due to the isolated locations of the fuel storage farms.

The most significant regulatory codes from the standpoint of fire safety are fire prevention and building codes. The County implements the Uniform Building Code (UBC) and the Uniform Fire Code (UFC). These uniform codes are intended to serve only as minimum standards. Therefore, it is important that these minimum fire safety standards be strictly enforced by fire and building agencies in the unincorporated County.

The Imperial County Codified Zoning Ordinance also contains provisions which act to reduce fire hazards. The Zoning Ordinance is a tool that helps prevent the construction of incompatible or hazardous structures. For example, the ordinance separates industrial, commercial and residential uses and provides for the isolation of land uses that may create excessive fire exposure to other properties. It also limits the height and bulk of buildings, specifies setbacks and distances between buildings.

The Imperial County Subdivision Ordinance is also used to reduce the risk of fire by securing, as a condition of subdivision of land, water systems of adequate size and pressure for fire fighting, and adequate roadway widths for emergency service vehicle access including maneuverability of fire trucks. As part of the review process, the Imperial County Planning Department seeks recommendations from fire and water districts wherever the proposed subdivision is located.

The County of Imperial Fire Prevention and Explosives Ordinance, Section 53101-53300, contains provisions for the purpose of prescribing regulations governing conditions hazardous to life and property from fire or explosion. Such measures in this Ordinance include the following:

Storage of flammable materials
Storage of Radioactive materials
Permit required for sale and use of fireworks
Abatement of weeds and other vegetation

The Fire Prevention Education Program encompasses a public information and education component that promotes public awareness of the significance of Fire/Safety prevention measures. This program enables the public to be better prepared when an emergency fire situation occurs.

D. Hazardous Material Accident

A hazardous material accident could occur in Imperial County due to the agricultural economy, proliferation of fuel tanks and transmission facilities, intricate canal system, and the confluence of major surface arteries and rail systems. Although a hazardous material accident can occur

almost anywhere, particular regions are more vulnerable. The potential for an accident is increased in regions near roadways that are frequently used for transporting hazardous material, and in regions with agricultural or industrial facilities that use, store, handle, or dispose of hazardous material.

The release of hazardous material into the environment could cause a multitude of problems. The release of explosive and highly flammable materials have cause fatalities and injuries, required large-scale evacuations, and destroyed millions of dollars worth of property. Toxic chemicals in gaseous form have caused injuries and fatalities among emergency response teams and passerby. Serious health problems have occurred where toxins have entered either surface or groundwater supplies. Serious health problems have occurred. Releases of hazardous chemicals have been especially damaging when they have occurred in highly populated areas, or along heavily traveled transportation routes. The decree of threat posed to life and property is dependent on the type, location, and concentration of the material released, in addition to prevailing weather conditions such as precipitation, wind speed, and wind direction. Appendix B contains a summary of hazardous material storage sites, handlers, and vendors.

The Laidlaw Environmental Services hazardous waste facility located west of Westmorland is unique in the sense that a major wash traverses the site. Substantial engineering design was utilized to minimize flooding, and channel maintenance requirements have been implemented. While the facility does pose a potential risk, the continued monitoring and stringent design standards imposed on the facility have minimized the probability of a serious failure. Special reports on design requirements and risk concerns are on file at the Planning Department.

A second type of facility which is more predominant and more difficult to assess. These facilities is the chemical handling and storage facilities and include distributors, transporters, and crop dusting firms. These firms are not permitted to store the various chemicals in open areas, or in buildings not adequately protected from flood conditions. During severe flooding the potential for these chemicals to be mixed with the flood water can pose a potentially serious health concern.

Pursuant to Section 25500 et seq. of the California Health and Safety Code, the County Health Services Department is designated as the "administering agency" responsible for maintaining a list of handlers/vendors of toxics within the County. In addition, they are required to maintain, for each handler/vendor, to maintain an inventory and business plan. This information is also available to the County Fire Marshal and city fire departments. The "Imperial County Emergency Plan" (1988) lists the ten largest concentrations of toxics in the County, which are shown on Figure 5 and are: (1) Naval Air Facility El Centro; (2) Santa Fe Pacific Pipe Line Tank Farm; (3) ST Services; (4) 89.92 miles of fuel pipelines; (5) Brea Agricultural Service; (6) United Agriculture Products; (7) Puregro Company: (8) Rockwood Chemical Company; (9) Helena Chemical Products; and (10) Wilbur Ellis Company.

E. Lifelines and Critical Facilities

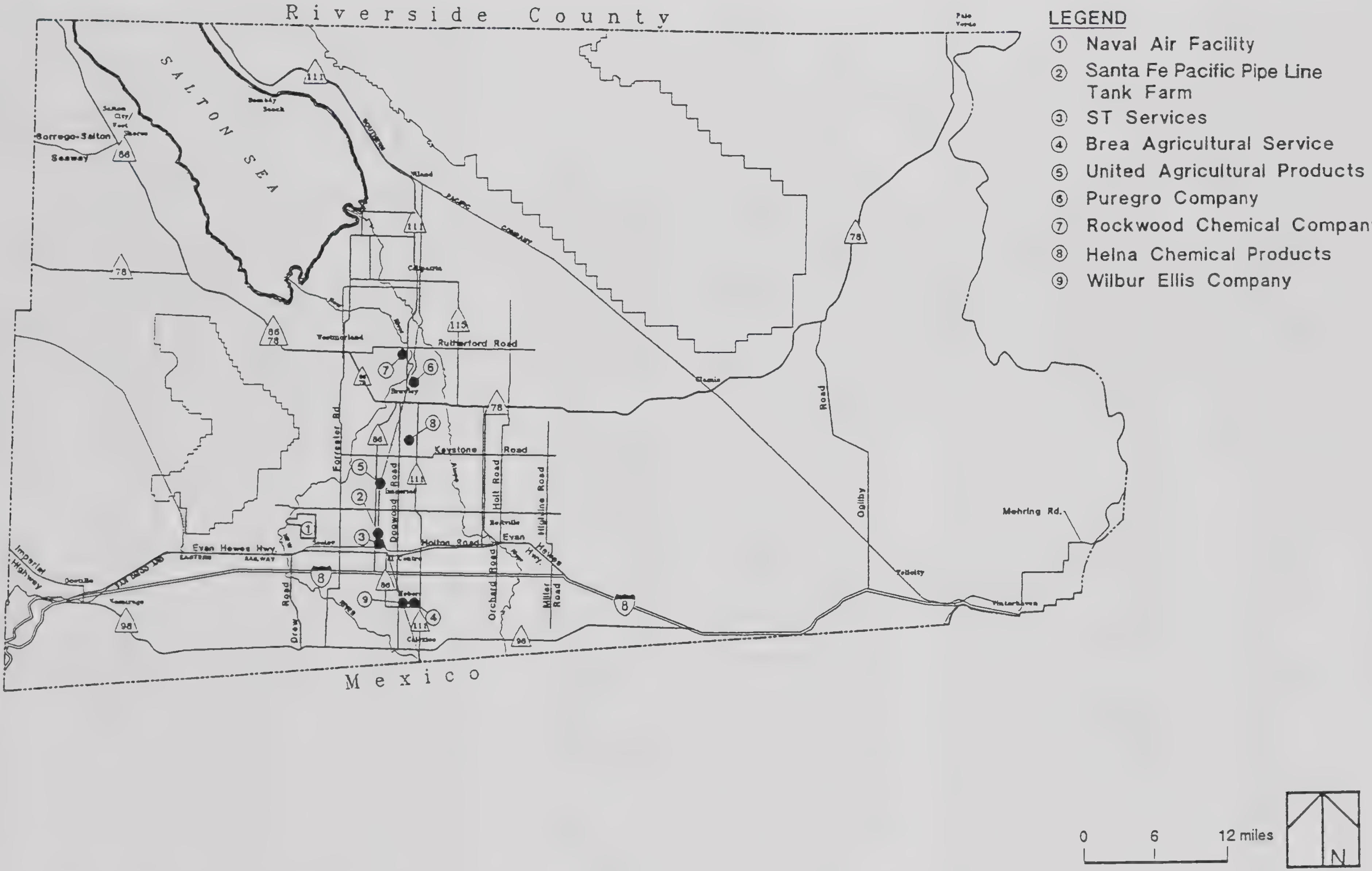
The disruption of lifelines and critical facilities can endanger the safety of the public. Lifelines refer to networks of services that extend over a wide area and are vital to the public welfare. Lifelines typically involve supply sources, transmission lines, storage facilities, and distribution systems. Damage to any one of these key elements might cause loss of service to large areas or the entire service area. Lifelines can be classified into four categories: Energy, Water Transportation, and Communication. These categories circumscribe the lifelines indicated in Table 1.

TABLE 1
SUMMARY OF LIFELINES

	Energy	Water	Transportation	Communications
Type of Lifelines	Electricity Liquid Fuel Gas	Potable Water Sewage Solid Waste	Highway Railway Airport Harbor	Telephone Telegraph Radio Television Mail Press

Energy. Electricity is provided to the vast majority of Imperial County and the Coachella Valley area of Riverside County by the IID. The transmission and distribution system is moderately resistant to earthquakes. When parallel overhead power lines have too much slack or sag unevenly, they may come in contact with one another during an earthquake. The resulting arcing could cause conductors to burn and fall to the ground. On the other hand, if overhead powerlines are too taut, they could snap and fall to the ground from earthquake shaking. Overhead powerlines can also be broken by objects jostled from earthquake shaking, (e.g., trees, antennas). The entire electrical distribution system is protected by relays designed to prevent current overload. Seismic vibrations themselves can cause the relays to "trip" and cut off power. Such an abrupt power disruption could cause current overloads in other parts of the system. As a result, other relays could trip and cut off more power. Although the risk of serious damage to the distribution system is low, the risk of partial or total loss of power is fairly high.

The IID's generating facilities and sources of power are varied and dispersed across the County. The probability is low for all of the facilities being disrupted simultaneously. The main generating facilities are El Centro (180 megawatts), Brawley (18 megawatts), Rockwood (50 megawatts), and Coachella (80 megawatts). Hydroelectric facilities along the All American Canal have a maximum capacity of 45 megawatts. All of these facilities are located in seismically active zones. The facilities are also located within 15 miles of each other with the



Imperial County General Plan

Hazardous Material Sites

Seismic and Public Safety Element

Figure 5

exception of the Coachella plant and the hydroelectric facilities. The probability of all of the plants being disrupted during a seismic event is considered low. A break in the All American Canal could also reduce electricity generation.

Liquid petroleum products are delivered to and are transported through the County via the twenty-inch Santa Fe Pacific Pipe Line. This line is generally located within the Southern Pacific Railroad right-of-way. The right-of-way follows the northwest to southeast trend of Imperial Valley and subsequently parallels the major faults. It passes near the east side of the Salton Sea and serves the storage facility at Niland. Southeast of Obilby, the line turns east and travels to Yuma. A six-inch branch line distributes gas to the storage facility south of Imperial and a four-inch line serves the Naval Air Facility near Seeley. The maintenance staff for the line anticipates no special problems from earthquakes or fault movement and are unaware of such a situation occurring in California in past years. A major break would take one to two days to repair.

The petroleum storage facilities in Niland and Imperial are vulnerable to earthquakes. Storage capacity at Niland is 77,500 barrels and at Imperial is 289,000 barrels. Storage tanks, however, are never full at one time but are normally filled fifty percent. The 1979 earthquake resulted in the rupture of one tank and a gasoline leak of 100 gallon per minute at the Imperial facility. The potential for a major disaster does exist. The probability of loss of all liquid petroleum in the County is low. Emergency service via tanker is readily available if required during an emergency situation.

Natural gas is delivered by the Southern California Gas Company via twin ten-inch lines which generally run south through the County in Range 14 East. These lines serve Niland, Calipatria, Brawley, Imperial, El Centro, Heber, and Calexico and branch lines serve Holtville, Westmorland, Seeley, NAF, and Plaster City. Rural residents are served by laterals from the branch lines. The lateral lines typically do not exceed a quarter mile in length.

The gas lines are less resilient to seismic stress than the liquid lines and the entire natural gas system is vulnerable to disruption. The lines were damaged from the 1979 earthquake. The north-south line was damaged in the area it crossed the fault. The line suffered compressive stress and a fitting buckled and resulted in a major leak. The leak was repaired without shutting down the line. The line to Holtville was stretched where it crossed the fault. The line did not break and was repaired without shutting down the line.

The natural gas network is much more extensive than the liquid petroleum system. Leaks are more insidious. The risk of an explosion or fire is greater. The most serious potential hazards are at the customer service connections. Gas connections to hot water heaters are notably vulnerable to seismic shaking.

The biggest potential problem would result from damage that required shutting the natural gas delivery system down. A major rupture of the ten-inch line would be difficult to repair. Once pressure was lost and air entered the system, a total shut down would be required. Service

personnel would have to visit the customer connections at each twice. The initial visit would be require to insure that the gas was turned off. The second visit would be required to turn the gas back on, bleed the air, and assist in relighting fixtures. This would be a massive job that would take weeks. The main purpose of the twin lines is to avoid this type of disaster.

Water and Sewer. About seventy percent of the population is provided potable water for domestic purposes from municipal water systems, which are primarily served by the Imperial Irrigation District (IID). Rural residents obtain potable water from truck delivery companies, such as the AAA Company, or from individual wells. IID operates 1700 miles of canals; and the Coachella Irrigation District operates 83 miles of canals that traverse the County. The entire system is vulnerable to disruption by earthquakes. Approximately half of the system could generate flooding from a break. IID has adopted the Disaster Readiness Standard Operating Procedure to respond to earthquakes and other emergencies.

A number of the communities in the County are provided sewer service by municipal districts. Earthquakes can rupture line and affect lift station operations. These problems are not considered serious. Unless the seismic event totally disables the treatment plant, sewage can be transported using alternative means such as portable pumps and lines. In the event of a complete plant failure, temporary evaporation ponds could be utilized for the interim repair period.

Transportation. The County is well served by a variety of transportation routes which are unlikely to be so extensively damaged by a natural disaster as to endanger the public safety due to disruption of lifelines. Interstate 8 to San Diego County is potentially the most critical because it goes through mountainous terrain. No other convenient surface route to the metropolitan San Diego area exists. The Southern Pacific Railroad line along the east side of the Salton Sea is also endangered by its proximity to the San Andreas Fault. Severe damage to either of these facilities is likely to significantly impact local and interstate commerce, but not substantially threaten public safety.

Communications. The telephone system in the County is the most elaborate communication network in the country. The equipment and facilities can withstand earthquakes up to 8.0 on the Richter scale. An Emergency Preparedness Plan has been developed by the telephone company. The telephone network is designed to service sixty percent of the customers requesting dial tone.

The telephone system was not damaged by the 1979 earthquake, but was overloaded with attempted phone calls within minutes of the earthquake and remained essentially inoperative for up to 18 hours in parts of the County. There is a high probability that the telephone system would be significantly dysfunctional following a major earthquake. The Countywide Communication Plan was adopted in 1980 and provides direction for communication via the various radio networks when there are no telephone capabilities. Due to problems with the telephone system immediately after the 1979 earthquake, the IID installed its own in-house telephone system that utilizes a microwave system. The microwave towers have been designed to withstand the most severe earthquake.

Critical Facilities. This refers to site specific facilities that serve to maintain the health, safety, and general welfare of the public. Critical facilities can serve the public under normal circumstances (e.g., hospitals, fire stations, water reservoirs, and power plants) or under emergency circumstances (e.g., emergency operating centers, armories, or disaster supply wherehouses). The "Imperial County Emergency Plan" provides specific details on functional, organizational, and operational concepts and procedures for the provision of critical services during an emergency. This includes overall management of emergency operations, fire and rescue, law enforcement and traffic control, medical, public health, coroner, care and shelter, evacuation movement, construction and engineering, and resources and support operations.

F. Disaster Preparedness

The "Imperial County Emergency Plan" also addresses Imperial County's planned response to extraordinary emergency situations associated with natural disasters, technological incidents, and nuclear defense operations. The plan does not apply to normal day-to-day emergencies and the routine procedures used in coping with such emergencies. Instead, the operational concepts in the Emergency Plan focus on potential large-scale disasters that can generate unique situations requiring unusual responses. Such disasters pose major threats to life and property and can impact the well-being of large numbers of people. The Emergency Plan also identifies the sources of outside support which might be provided by other jurisdictions, state and federal agencies, and the private sector through mutual aid and specific statutory authorities.

III. GOALS AND OBJECTIVES

A. Preface

The Seismic and Public Safety Element of the General Plan is to be consulted in the implementation of development policies and land uses in Imperial County. This section (Chapter III) of the Seismic and Public Safety Element presents Imperial County's Goals and Objectives relative to all land use decisions within the unincorporated areas of the County. They have been prepared in collaboration with the General Plan Ad-Hoc Advisory Committee appointed by the Board of Supervisors.

The Goals and Objectives, together with the Implementation Programs and Policies in Chapter IV, are the statements that shall provide direction for private development as well as government actions and programs. Imperial County's Goals and Objectives are intended to serve as long-term principles and policy statements representing ideals which have been determined by the citizens as being desirable and deserving of community time and resources to achieve. These Goals and Objectives, therefore, are important guidelines for public safety decision making. It is recognized, however, that other social, economic, environmental, and legal considerations are involved in land use decisions and that these Goals and Objectives, and those of the other General Plan Elements, should be used as guidelines but not doctrines.

B. Goals and Objectives

Land Use Planning and Public Safety

Goal 1: Include public health and safety considerations in land use planning.

Objective 1.1 Ensure that data on geological hazards is incorporated into the land use review process, and future development process.

Objective 1.2 Regulate development within flood-way areas in accordance with Federal Emergency Management Agency (FEMA).

Objective 1.3 Regulate development adjacent to or near all mineral deposits and geothermal operations.

Objective 1.4 Require, where possessing the authority, that avoidable seismic risks be avoided; and that measures, commensurate with risks, be taken to reduce injury, loss of life, destruction of property, and disruption of service.

Objective 1.5 Encourage other governmental agencies and the private sector to pursue an objective similar to Objective 1.4.

Objective 1.6 Ensure environmental hazards are considered when siting critical facilities.

Objective 1.7 Require developers to provide information related to geologic and seismic hazards when siting a proposed project.

Objective 1.8 Reduce fire hazards by the design of new developments.

Objective 1.9 Encourage the reclamation of lands where mining, irrigation, landfills, solid waste, hazardous materials/waste storage or disposal, and natural soil erosion has occurred, so as to pose no danger to public health and safety.

Objective 1.10 Encourage underground pipelining of all open canals adjacent to and within urban areas to prevent accidental drownings, without placing unreasonable cost burden on agricultural water users.

Objective 1.11 Recognize that certain lands are unsuitable for high density development and that prohibition or restriction of such high density uses are in the public interest, health, and safety.

Emergency Preparedness

Goal 2: Minimize potential hazards to public health, safety, and welfare and prevent the loss of life and damage to health and property resulting from both natural and human-related phenomena.

Objective 2.1 Ensure the adequacy of existing emergency preparedness and evacuation plans to deal with identified hazards and potential emergencies.

Objective 2.2 Reduce risk and damage due to seismic hazards by appropriate regulation.

Objective 2.3 Identify potential risk and damage due to inundation from dam failure and/or water releases.

Objective 2.4 Support and assist in informing the public and other agencies of the hazards and risks of earthquakes and of techniques to employ to reduce those hazards.

Objective 2.5 Minimize injury, loss of life, and damage to property by implementing all state codes where applicable.

Objective 2.6 Maintain, utilize, and provide geologic and seismic information as furnished by the State Geologist as required.

Objective 2.7 When appropriate situations are identified, require rehabilitation of buildings that pose a public hazard due to inadequate seismic design, or presents a structural hazard.

Objective 2.8 Prevent and reduce death, injuries, property damage, and economic and social dislocation resulting from natural hazards including flooding, land subsidence, earthquakes, other geologic phenomena, levee or dam failure, urban and wildland fires and building collapse by appropriate planning and emergency measures.

Objective 2.9 Reduce vehicle accidents through appropriate standards.

Objective 2.10 Reduce the risk of damage due to subsidence resulting from extraction of groundwater and geothermal resources by appropriate regulation.

Control Hazardous Materials

Goal 3: Protect the public from exposure to hazardous materials and wastes.

Objective 3.1 Discourage the transporting of hazardous materials/waste near or through residential areas and critical facilities.

Objective 3.2 Minimize the possibility of hazardous materials/waste spills.

Objective 3.3 Discourage incompatible development adjacent to sites and facilities for the production, storage, disposal, and transport of hazardous materials/waste as identified in the County General Plan and other regulations.

Objective 3.4 Adopt and implement ordinances, policies, and guidelines that assure the safety of County ground and surface waters from toxic or hazardous materials and wastes.

C. Relationship to Other General Plan Elements

The Seismic and Public Safety Policy Matrix (Table 2) identifies the relationship between the Seismic and Public Safety Element Goals and Objectives to other Elements of the Imperial County General Plan. The Issue Area identifies the broader goals of the Element and the "Xs" identify that related objectives are contained in the corresponding Elements.

TABLE 2
SEISMIC AND PUBLIC SAFETY ELEMENT POLICY MATRIX

Issue Area	Land Use	Housing	Circulation	Noise	Agricultural	Open Space Conservation	Geothermal	Water
Land Use Planning	X	X	X			X	X	
Emergency Preparedness	X						X	
Hazardous Materials	X		X					X

IV. IMPLEMENTATION PROGRAMS AND POLICIES

A. Preface

This Chapter provides an implementation program to reduce the threat of seismic and public safety hazards within the unincorporated areas of the County. The natural hazards discussed in this Chapter are relative to Imperial County's geography, geology and flooding and is divided into three major topics: Seismic/Geological Hazards; Flood Hazards; and Imperial Irrigation District Lifelines.

B. Programs and Policies

Seismic/Geologic Hazards

1. Implement codified ordinances and procedures which require the review and restriction of land use due to possible natural hazards.

2. Monitor, evaluate, and analyze existing seismic and geological data as it pertains to Imperial County to determine future regulations and programs.

3. Implement the geologic hazards section of the County's Codified Ordinances pursuant to the requirements of the Alquist - Priolo Geologic Hazards Zone Act.

4. Ensure that no structure for human occupancy, other than one-story wood frame structures, shall be permitted within fifty feet of an active fault trace as designated on maps compiled by the State Geologist under the Alquist - Priolo Geologist Hazards Zone Act.

5. The County should require suppliers of all existing utilities which cross active faults to file with the County an operation plan describing the probable effects of failures at the fault and the various emergency facilities and procedures which exist to assure that failure does not threaten public safety.

6. Ensure that proposed highway construction which falls within an Alquist - Priolo Act Special Studies Zone shall be reviewed to ensure that grade-separated interchange structures are not located on or near an active fault.

7. Periodically update maps of existing faults, slide areas, and other geographically unstable areas in the unincorporated area of the County.

8. Support the safety awareness efforts of the Office of Emergency Services of Imperial County and other agencies through public information and educational activities.

9. Continue to implement the Alquist - Priolo requirements in designated special study zones in the Imperial County Ordinance.

Flood Hazards

1. Provide technical and policy information regarding flood hazards to developers, interested parties, and the general public.

2. Regulate and restrict development near major water courses and floodplains through application of appropriate land use measures.

3. Both the ground floor elevation of any building for human occupancy and the driving surface, if designated evacuation routes within the 100-year floodplain, shall be constructed above the projected profile of a 100-year flood event.

4. Require all new development for human occupancy within the 100-year floodplain to be adequately flood-proofed.

5. Establish technical design criteria which minimizes or mitigates impacts associated with crossing of floodplains by development. Unless such engineering alternatives are implemented, development in floodplains is to be restricted or prohibited.

Imperial Irrigation District Lifelines

Imperial Irrigation District has a formal Disaster Readiness Standard Operating Procedure for the Water Department, Power Department, and the entire District staff for response to earthquakes and other emergencies. The general policy for the Water Department is as follows:

1. Cooperate with the Imperial County Office of Emergency Service.

2. Lower the level in canals after a need has been determined, and only to the extent necessary.

3. If the need arises, divert the entire flow of the All American Canal at Pilot Knob back into the Colorado River; and divert the remaining water into the Alamo and at the New River where the canal crosses those rivers.

4. Routinely hold water in many of the canals by check gates to maintain availability for domestic uses. This would also be available for fire fighting

APPENDIX A

SEISMIC SAFETY TECHNICAL REPORT

INTRODUCTION

In terms of seismic activities, Imperial County is similar to most regions bordering the Pacific Ocean. It is an area of high seismic activity. Most of the seismic activity is in the Salton Trough (Imperial Valley) consequently, the Valley is subject to potentially destructive and devastating earthquakes. (Imperial Valley in this instance, encompasses the central area, commonly known as the "irrigated" area.)

Earthquakes, are the result of an abrupt release of energy stored in the earth. This energy is generated from the forces which cause the continents to change their relative position on the earth's surface. This process is called "plate tectonics."

The earth's outer shell is composed of a number of relatively rigid plates which move slowly over the comparatively fluid molten layer below. The boundaries between plates are where the more active geologic processes take place. Earthquakes are an incidental product of these processes.

California rests on the boundary between the North American Plate and the Pacific Plate. The San Andreas Fault system is located where the northwesterly drifting Pacific Plate grinds along and is subducted by the southwesterly drifting North American Plate. Baja, and California west of the fault system, are part of the Pacific Plate and move northwest compared to the rest of California and North America. The relative motion is two inches per year, but the plates do not slide easily past each other as they do over the molten layer below. They stick until the strain exceeds the elastic capacity of the rock which then fractures and allows the sudden movement which is an earthquake.

When sudden movement ruptures the earth's surface, it causes vibrations called seismic waves. Complex methods and equipment have been developed to measure earthquakes. Magnitude is a measurement of the energy released. Intensity is a measurement of the damage done. Earthquake prediction methods have been developed, but at this time it is not possible to tell when or where a quake will occur with any reliability.

Effect of Earthquakes

The principal seismic hazards in Imperial County are (1) ground shaking including differential ground settlement, soil liquefaction, rock and mudslides, ground lurching, and avalanches; (2) ground displacement along the fault; (3) floods from dam and levee failure, and seiches; (4) fires; and (5) the various adverse results of disruption of essential facilities and systems - water, sewer, gas, electricity, transportation, and communication (and notably in Imperial Valley, the irrigation and drainage system).[1]

Ground shaking is by far the most important hazard. However, many people believe that fault displacement is the greatest danger. In accordance with the Alquist - Priolo Special Studies Zone

Act (Chapter 7.5, Division 2, Public Resources Code, State of California, effective May 4, 1975) the Office of State Geologist delineated Special Study Zones which encompass potentially and recently active traces of four major faults (San Andreas, Calaveras, Hayward and San Jacinto). These Special Study Zone Maps depicting active fault traces are available for public review at the Imperial County Planning Department and the Imperial County Public Works Department. The Alquist - Priolo Special Study Zone Act is enforced by the County to assure that homes, offices, hospitals, public buildings, and other structures for human occupancy which are built on or near active faults, or if built within special study areas, are designed and constructed in compliance with the County of Imperial Codified Ordinance.

An earthquake is the release of force built up by plate stress and triggered by some action; therefore an earthquake is the triggering event to permit the force of gravity to operate. Rockslides, mudslides, avalanches, slope slumping, and ground settlement illustrate this. Water saturated, sandy and fine grained soils subjected to vibrations may lose their shear strength, take on a liquid character, and fail to support structures (liquefaction). Buildings may "sink" into the soil; lighter structures may be buoyed up.

Seiches are earthquake generated waves in small bodies of water. Although there are no records of seiches in the Salton Sea, the following account from the Owens Valley quake of 1872 is instructive: "A huge wave developed in Owen Lake... the water (was) drawn away from the shore and standing in a perpendicular wall... But the return was fairly gentle so only 200 feet of new ground was covered by the waves."[2]

Floods from dam failure are a notable secondary effect of earthquakes. Often, in earthquake country, the most economical (and sometimes only) dam site is in a high risk seismic zone. The geological forces generating faults often produce the topographic features desirable for dams. Earthfill dams are obviously more susceptible to seismic induced failure than concrete or other structural dams.

In Imperial County, there are three major dams - Imperial, Laguna, and Senator Wash, located on the Colorado River; and in the irrigated area, several large, earthfill impoundment reservoirs; hundreds of miles of above ground level earth levee canals, and hundreds of check dams, drops and gates. The Colorado River is not a known seismically active zone and, to date, there have been no reported cases of earthquake damage to the dams there. Within the irrigated area, there have been a number of instances of levee failure from earthquakes and resultant flooding. Because of the comparatively small volumes of water involved, low head, variety of options to check or divert flows in the canals, and the ubiquitous drainage network, the flooding hazard is not great. Nevertheless, some hazard does exist and even minor flooding could be an incremental contribution to the other disruptions an earthquake might cause.

Effects on Structures

Five main factors effect building damage from earthquakes are:

1. The strength of earthquake waves. For record purposes, accelerations over 0.1g are considered "strong shaking" although this level generally does not produce significant

damage. Imperial County's two largest quakes; 1940 and 1979, produced .22g vertical, .36g horizontal, and .38g vertical, .40g horizontal, respectively, as measured at El Centro.[3]

2. The frequency of the waves. Ordinary structures respond mainly to shaking at frequencies higher than 1 Hz (1 cycle per second). These occur out to a maximum of about 20 miles from the epicenter. However, large structures such as large bridges, and/or high-rise buildings respond to frequencies as long as 10 Hz. These may be significant as much as 60 miles away.

3. The duration of the shaking. It is the cumulative effect of the shaking -- not the single pulse -- that affects structures and causes their collapse. Each shake can weaken part of the structure. Subsequent oscillations further weaken the structure especially if magnified by the resonance of the natural frequency of the structure with the frequency of the waves.

   Relating strength and duration, it is the "repeatable high ground acceleration (RHGA)" as opposed to the peak ground acceleration that is the main criterion in designing structures to be safe from ground shaking impacts. In this respect, aftershocks also play an important role. They frequently produce substantial damage to buildings weakened by the main shock sequence. The Kern County quake of July 21, 1952 had a magnitude of 7.3. However, most of the actual damage occurred a month later when an ordinarily mild 5.8 aftershock brought down the already weakened buildings.

4. The geologic foundation. Engineers and insurance companies often consider this the most important factor in building damage. Fill and "made" land, especially when saturated, transmits much greater intensity of motion than solid rock even when both are subjected to the same seismic waves. The greater stress on the structure, as well as the possibility of liquefaction, differential settlement, or slope failure, make a poor geological foundation and create a double jeopardy in earthquakes.

5. The building design. Where subjected to the effects of a major event, an "earthquake proof" building may, at least with current technology be impossible to design. . Architects and engineers know how to design earthquake resistant structures.

Buildings traditionally are designed first to resist the force of gravity. The traditional building techniques and materials are very good for this: post and beam, bricks, concrete. The loads are very easy to calculate and to design for; "dead load" representing the weight of the building itself, and the "live load" representing the contents of the building, wind, people, furniture, goods, etc. All of these are static and dynamic forces acting in the vertical plane. Often, in older buildings the main force holding the building together is the force of gravity itself - the upper parts pressing down on the lower parts.

When an earthquake occurs, it introduces vertical and horizontal dynamic forces. Newer buildings generally have reasonably large margins of safety designed into them to withstand the constant pull of gravity. Therefore they generally withstand vertical seismic accelerations reasonably well. However, horizontal accelerations and sudden rapid vertical acceleration are what cause the major damage.

During an earthquake, buildings usually fail at the location where their various parts are joined together. Weakened structural sections are then affected by gravity which then may cause them to collapse. The majority of buildings usually "pancake". They seldom fall or roll over. Because there are so many factors that affect the structural integrity of a building, it is possible to have two identical buildings exhibit substantially different results in an earthquake.

The second consideration in traditional building safety design is against fire (also a major secondary effect from earthquakes). Here too, the most resistant materials are stone, bricks, concrete, etc. As buildings became larger, and safer in their resistance to gravity and fire, and to weathering and wind, they become more massive and have greater inertia. Like the damaging seismic forces, wind is dynamic and also acts horizontally. Most of the wind resisting design techniques also resist earthquakes. However, whereas the inertia of massive buildings works positively to help resist horizontal wind forces, it can be detrimental in withstanding horizontal earthquake accelerations.

"Rigid Strength" buildings tend to hold together well with little or no damage from quakes up to the point at which some part fails and then the whole building may come apart... To design "rigid strength" to withstand the greatest expected quakes may require bulk and costs that would prevent the building from ever being built in the first place. There are numerous architectural designs that have been implemented across the world to minimize earthquake damage, such as massive shock absorbers, counter balance weights, floating support systems, etc. Unfortunately most of these solutions are only practical in very large and expensive structures.

The alternative to "rigid strength" is flexibility. Wood (in small buildings), and especially steel, permits construction that will bend and deform, and allow the energy of the earth movements to pass through the building rather than try to resist and absorb the energy. Flexibility permits the construction of buildings which are lighter, freer in design, much less costly, and which still won't completely fail under very large quakes. Wood has both tensile and compressive strength. It is usually readily available, is easy to work and assemble, and is thus both a popular and a fairly good earthquake resistant building material. Its notable failing is at the joints. Where bolts and screws, in addition to nails are combined with steel straps and "strong ties", and plywood is used for shear walls and horizontal diaphragms, quite excellent "flexible strength" can be built into wooden structures up to three stories high. Larger than this, the weight of the structure begins to exceed the "cost effective strength" of the lower floor wooden supports. Since flexible designs do permit various parts of a structure to move in relation to its other parts, damage such as cracked tile and plaster, shattered windows, and broken pipes, may occur from moderate quakes.

Because earthquakes involve dynamic oscillations, building design can also influence its reaction to a quake in ways not expected solely on the basis of strength to accommodate applied force. All things, including buildings, have a natural frequency at which they oscillate. If this natural frequency matches that of the passing seismic waves, the building oscillations may build up to a much greater amplitude than would otherwise occur.

Buildings with irregular layouts or abrupt changes in structural materials have been shown to suffer more earthquake damage than other buildings with the same "strength". Particularly vulnerable are buildings with mixed rigidity and flexibility. A classic example is the house in which a wall opening has been enlarged to install bigger windows. That wall now is weaker, but also more flexible than

its opposite wall counterpart. In a quake, most of the load previously carried by both walls, will be absorbed by the stronger, stiffer wall, and it may fail while the weaker, more flexible wall, remains intact.[4]

An aspect of building design is building orientation. In Imperial County, faults all trend northwest to southeast and fault movement is mostly strike slip. The waves from an earthquake can be expected to be stronger in the northwest/southeast direction. Wise residents in earthquake country are known to take such basic precautions as anchoring furniture, water heaters, and breakables such as china cabinets, in order to diminish hazards. Architects and engineers can apply this knowledge of predominant seismic wave orientation to building and site design.

The foregoing discussion on building design is not meant to suggest design alternatives, as much as to illustrate the necessity to think in terms of "trade offs" and cost versus risk. We cannot prevent earthquakes. We can build resistant characteristics into structures and avoid building those which are particularly susceptible to the effects of earthquakes.

Seiches

"A seiche is a to and from vibration of a body of water in its own natural tempo like the slopping of water in a jolted basin. Once started, the water body will continue to oscillate independently with its own proper period. Seismic sea waves are only one of the many causes of seiches which often occur also in lakes and ponds."[5]

While there have been a number of seismic events since the formation of the Salton Sea, to date seiches have not occurred to any significant recorded magnitude. There is, however, no guarantee that under specific circumstances one could not occur.

Although "the San Andreas Fault is known to be quite active in the Salton - Imperial Basin, it is difficult to define and almost impossible to trace."[6] In addition to the San Andreas fault, the San Jacinto Fault lies west of the Salton Basin and, on the east side of the Salton Sea, another fault trace is recognizable near Durmid, where sandstone and shale beds on the southwest side of the fault have been opened and contorted near the fault.[7]

Nevertheless, it is reasonable to believe that close proximity of these faults to the Salton Basin implies that the Salton - Imperial Basin could be subjected to an occurrence of significant seismic ground shaking in the future, thus, possibly inducing a seiche.

SEISMIC HISTORY IN IMPERIAL VALLEY

Reliable accounting of earthquakes began around the turn of the century when Imperial County became inhabited. What evidence exists, suggests that earlier seismic activity was similar to recent activity. Generally only events of intensity V or greater are included here.

The following accounts, (through 1970), are taken largely from *An Earthquake History of the United States* by the U.S. Department of Commerce. The accounts for after 1970 are compiled from a variety of sources, all listed in the reference section.

1853 November. Based on reported effects in distant towns, a large earthquake is believed to have occurred in the northern Salton Trough, probably in the Imperial Valley. A magnitude of 6.5 is estimated for this event.

1853 December. Fort Yuma. Many shocks. Possibly of destructive force.

1868 May. Los Palmas, east and north of Salton Sea. One source states that a long fissure opened in the earth. (If this is true, the intensity was IX, perhaps X).

1871 (Month Unknown). Imperial Valley. Halfway between Los Palmas and Yuma, the shock rolled men over who were sleeping on the ground.

1877 June 11. Imperial County. Violent vibrations preceded volcanic eruption in the mountains near Flowing Well Station, about 60 miles northeast of Yuma.

1892 February 23. Northern Baja California. The intensity of this shock probably reached X near the epicenter, which was apparently in the uninhabited region of northern Baja California. It was felt strongly along the Pacific coast of Baja California, as far as San Quentin, Mexico and as far north as Vislia, California. At Carrizo, all adobe buildings were destroyed; at Jamul, walls of stone kilns cracked. At Campo, there were 155 shocks in 12 hours. After shocks were numerous for several days.

1903 January 23. Baja California. A strong earthquake, centering in the uninhabited region south of Imperial Valley, was felt throughout southern California, southern Nevada, and western Arizona. A similar shock under present conditions in the Imperial Valley would cause damage. Recorded by distant seismographs. Magnitude 7+.

1906 March 3. Southern California. Felt widely in southern California. Origin south of border. Recorded by distant seismographs, which indicates moderately destructive power.

1906 April 18. Brawley, Imperial Valley. Chimneys fell. Banks of New River caved in; water tanks destroyed at Cocopah in Baja California. The published information is very limited, but H. O. Wood, on the basis of verbal information, reported this to be a very severe shock. Magnitude 6+. It came just hours after the great San Francisco quake and most probably was related.

1915 June 22. El Centro, Calexico, and Mexicali. Two destructive shocks, nearly 1 hour apart. Heavy damage (about $900,000) in southern Imperial Valley was caused as much by poor quality buildings as by the intensity of shock. In El Centro, well constructed buildings merely suffered cracks. At Mexicali, Mexico, people returned to buildings after the first shock; six were killed and many were injured by the second earthquake. Though a few cracks were formed in the alluvium, the irrigation ditches and works were damaged very little. The unstable banks of the New and Alamo Rivers slid down in many places. Several farmers observed that after the shocks, one-third more water was required for irrigation because of the cracks in the soil. Despite the rather high local intensity, the total energy was moderate. Magnitude 6 1/4 for both shocks.

1915 November 20. Baja California. A shock, revealed by seismograms to have been considerably greater than that of June 22, occurred in the Volcano Lake region south of the Mexican boundary. In the Imperial Valley, the highest intensity was at Calexico; at Volcano Lake, levees and damp ground were cracked. Magnitude 7.1.

1917 May 27. Imperial Valley. Seems to have been most severe in open country. Walls were reported cracked at Brawley.

1918 April 30. Calexico, Plate glass broke. Felt over an area of about 100 mile radius.

1919 September 29. Baja California. Levees slumped and many longitudinal cracks were formed in the Volcano Lake region south of Imperial Valley. Reported intensity distribution suggests that more than one shock occurred. A few fore shocks and numerous after shocks.

1919 October 1. Baja California. A shock similar in location and energy to that of September 29.

1921 September 8. South of Imperial Valley. Duration at Calexico 30 seconds, than a second shock of same duration. Felt over a large area; probably of destructive intensity in the epicenter area.

1923 November 5. Calexico. The epicenter was probably near Calexico where a hotel shifted several inches on its foundation and other buildings sustained minor damage. Intensity was about the same at El Centro.

1923 November 7. Baja California. Intensity VII at Calexico. Damage caused by the shock of November 5 was increased, and one fire resulted. A stronger shock than that of November 5. Epicenter appears to have been in Baja California, south of Calexico.

1925 April 15. Calexico. Plaster was shaken from walls; inhabitants fled to the streets. Again, the epicenter probably was a short distance south of the border.

1926 April 19. Baja California. Volcano Lake region. Light at Calexico, duration 20 seconds. Seismograms indicate energy sufficient to be destructive over a small area. Felt as far as San Diego.

1927 January 1. Imperial Valley, near Mexican border. Two heavy shocks about an hour apart began a long earthquake series, though none of the latter exceeded VI in intensity. In Calexico and Mexicali many buildings were damaged, water mains broke, and some fires ignited. Between 15 and 20 persons were injured. At Heber, El Centro, and Imperial, slight damage was reported. At Heber, telephone service was interrupted. Magnitude 5 3/4 and 5 1/2, respectively. The after shock of February 12, 00:59, was farther north and was felt as strongly at Brawley as the main shocks. Hundreds of aftershocks occurred.

1930 February 25. Imperial Valley. At Westmorland, walls cracked, chimneys toppled and inferior buildings were damaged. Mud craterlets were found a few miles east of Westmorland. Several fore shocks and many after shocks. Magnitude 5.0.

1930 March 1. Imperial Valley. This shock was of smaller magnitude than that of February 25. At Brawley, brick buildings were damaged, chimneys were thrown down, and plate glass shattered. Structural damage included falling of cornice sand walls, severe cracks in walls, and displacement of roofs. Well-constructed buildings sustained little damage. Magnitude 4.5.

1934 December 30 and 31. South of Calexico. Two separate main events, the first, magnitude 6.5 and the second 7.1. It is difficult to determine which event caused what damage. Railroad bridges were damaged and tracks twisted. Surface cracks appeared. Water sprouted in dry river beds. Adobe houses were wrecked and a large water tower was thrown down. Irrigation ditches were damaged, roads buckled and communication systems disrupted. It was felt strongly in Tijuana. Chimneys and walls were thrown down at Calipatria. Intensities XI and X in Baja, VI and VII in Imperial Valley.

1940 May 18. Imperial Valley. Sixty thousand square miles affected in the United States (including Arizona and Nevada) and an unknown area in Mexico. The epicenter was located southeast of El Centro, but there was surface slipping with surface rupture over a known distance of 40 miles. The existence of the Imperial Fault was revealed for the first time. The horizontal displacement reached 19 feet near the border. Vertical displacements up to 4 feet were observed. There was damage at all towns in the Imperial Valley and canals were damaged with serious interruption to water service.

The Alamo Canal (still in use) was opened by the displacement causing a local flood south of the border.

At Imperial, the city water tanks collapsed and 80% of the buildings were damaged. At the more heavily populated town of Brawley, there was greater total damage but less percentage of loss. Possibly 40% of the buildings were damaged, but the percentage was higher in business buildings.

At Holtville, the city's water tank collapsed, but the damage was not great. Damage at Calexico and at Mexicali, Mexico was not as extensive as might have been expected. The principle loss in Mexicali was fire set by a short circuit.

Indirect loss of crops was considerable; direct earthquake loss in the United States was 6 million dollars. Nine lives were loss. Magnitude 7.1, intensity X.

Again, the rest of the decade was relatively quiet. There were eight quakes of magnitude 5 or greater in the area. Six of these came in 1942, with five of these on October 21-22. A landslide damage the SD&AE railroad bridge in Carrizo Gorge and some cracked plaster was reported throughout the Imperial Valley. A 5.4 event centered south of Borrego, January 8, 1946, caused no damage.

1950 July 29. Imperial Valley. Strongest of the series of shocks centering near Calipatria on July 27, 28 and 29. Fifty thousand dollars in damage resulted, chiefly from merchandise being thrown from the shelves in the Calipatria, Westmorland, and Niland areas. In Calipatria, concrete standpipes broke and a small railroad bridge shifted six to eight inches. There was considerable plaster damage. In the outskirts, sand boils appeared and irrigation ditch banks sloughed. In Westmorland, reinforced concrete walls of the post office building cracked and window broke at the

City Hall and at the Food Center Building. Also felt at Parker and Yuma, Arizona. Magnitude 5.4. A 4.7 aftershock August 1, caused sand boils and ground fissures around the North End Dam.

1951 January 23. Near Calipatria, cracked Westside Main canal. Magnitude 5.6, intensity VII.

1953 June 13-13. Brawley-Westmorland area. Landslides at Tamarack Road and the New River. Windows broken and plaster cracked. First event and aftershock of 5.5, intensity VII.

1954 November 12. A 6.3 event in Baja was strongly felt in the Imperial Valley.

1955 December 16. Brawley area, magnitude 5.4, intensity VII.

1957 April 25. South end of Salton Sea slight damage in El Centro, Brawley and Westmorland, magnitude 5.2, intensity VII.

1958 November 30. Main shock of a series caused minor damage at Calexico and Seeley. Magnitude 5.8, intensity VII.

1963 June 11. A 5.8 event in Baja was felt widely in Imperial Valley.

1965 June 15. A 4.5 main event in a series. Slight damage to buildings, broken windows, and "residents alarmed" in Brawley and Westmorland.

The history of seismic events is also a history of improvements in recording earthquakes and in understanding of seismic phenomena. Two events at this time are notable more for what they revealed about earthquakes than for damage that occurred.

1966 March 4. Imperial. Magnitude 3.6. This quake caused virtually no damage, but did cause surface rupture and horizontal displacement. It is the smallest known earthquake to do so. (Some authorities question these effects.)

1968 April 9. South of Ocotillo Wells. The main shock of a series was felt over a large area of California, Arizona, and Nevada. Minor ground cracking and displacement occurred on the Coyote Creek Fault, and Highway 78 was cracked and adjacent to Ocotillo Wells. Ground cracking, minor building damage, and power disruption occurred in some areas of Imperial Valley. A 200-foot long, 2 inch wide crack occurred in a road 6 miles west of Imperial. Minor damage was also sustained at Calexico, El Centro, Los Angeles, San Diego, and Yuma Arizona. Magnitude 6.5. Intensity VII. Later an aftershock of magnitude 5.2 was widely felt. The significant feature of this earthquake was the triggering of minor ground ruptures on neighboring Superstition Hills Fault, Imperial Fault, and the Banning Mission Creek portion of the San Andreas Fault. A 4.7 aftershock at Calexico knocked down plaster. A 4.4 event, listed as an aftershock, occurred at Salton City on May 22.

1969 May 19. A 4.5 quake near Borrego Springs was felt in San Diego, Riverside and Imperial Counties. There was no damage.

1971 September 30. Superstition Hills area, magnitude 5.1. No known effects.

1975 January 23-25. Eight events from 4.0 to 4.8 in the Brawley are. The smallest, on January 23 was assigned the highest intensity VII, but there was no significant damage recorded.

1975 June 20. Two events at Mexicali of 4.1 and 4.2.

1976 November 4. Eight events from 4.0 to 4.9 in the Calipatria area with no recorded significant effect.

1977 October 20 to November 14. Eight events from 4.0 to 4.3 southeast of El Centro, but with no recorded damage or effects.

Seismic activity from 1940 to 1979 was characterized by "earthquake swarms" with little or no damage. These were in addition to and sometimes associated with the individual events and series of events listed above. They occurred in 1950, 1955, 1966, 1973, 1975 and 1976. For example, eighty-two separate tremors were reported felt in Brawley between December 16 and 20, 1955. The 1975 Brawley swarm was studied in detail by C.E. Johnson and revealed complex interaction between the Brawley and Imperial Faults. These "swarms" were composed of dozens, and sometimes hundreds, of events in the range of 2.0 to 4.0.

Seismic monitoring arrays installed by Chevron and Union Geothermal Companies, to assist in their exploration of the geothermal reservoirs and to determine what effects their operations might cause, have semitivities of 1.0 Richter magnitude. They frequently reveal hundreds of events daily. There is no easy way to tell if these "swarms" and "microseismicity" (events less than 2.0 Richter magnitude) are normal to the Valley and not recorded in earlier years, or are a change in the normal pattern.

1979 October 15. The earthquake occurred at 4:16 p.m. (PDT). The epicenter was on the Imperial Fault approximately 12 miles south of the Mexican border and 12 miles east of Mexicali. It was widely felt throughout Southern California, and was assigned a magnitude of 6.6 ML (Richter). Two aftershocks of 5.0 or greater occurred by 9:00 p.m.

Approximately 100 persons were reported injured; two were hospitalized. The six story County Services Building, the largest building ever built in Imperial County, suffered the most notable damage resulting in its subsequent demolition and total loss. It was occupied by 400 persons at the time of the quake. None were seriously injured. Commercial damage was widespread, particularly in the older sections of Imperial, Calexico, Brawley, El Centro, and Mexicali. Sixty percent of the commercial buildings in Imperial were subsequently condemned. Windows and bottle goods were the major loss. One hundred and three mobile home units in El Centro were knocked from their piers, Throughout the quake area (in Imperial County) two homes were destroyed and 1,565 damaged. Broken windows, cracked plaster, and collapsed brick chimneys were typical.

One 30,000 gallon gasoline tank (among 18 at the Southern Pacific Tank Farm at Aten and Clark Roads) were ruptured and began leaking 100 gallons per minute. It was controlled by the next morning. All roads within one mile were closed and ten families in the area were evacuated.

There were 15 ruptures of water mains in El Centro and a temporary loss of ninety percent of the fire fighting capability. The Southern Pacific Railroad tracks were offset nine inches where they cross the Imperial Fault. Traffic was halted for 30 hours. Interstate 8, Routes 98 and 80 were damaged where they crossed the fault. The New River Bridge west of Brawley suffered serious damage by an aftershock about midnight. The west end of Runway 26 at the Naval Air Facility settled. The runway was closed 62 days for repairs. Sewage treatment plants in El Centro, Brawley, and Imperial were seriously disrupted. Clarifiers at all three were knocked out, pumps at Imperial were misaligned and subsequently burned out, and miscellaneous other damage occurred. All exceeded their holding capacity and dumped raw sewage into the drainage system. Normal service was not restored for from 2 to 6 months. Estimates of sewer main ruptures have never been summarized.

The All American Canal suffered major slumping to its embankments on both sides for an eight mile stretch in the vicinity of the Imperial Fault. There were extensive slope failures in many of the other canals. The IID immediately reduced flow to about fifteen percent and later shut the entire irrigation system down for several days for inspection and repairs. (Although media accounts, and the "staff report" state this, the system never was completely "shut down".) There was extensive drainage tile damage in fields crossed by the fault.

Electrical power was out in parts of the Valley for 3 to 4 hours. Several key emergency generators failed to function - one for the County fire station and control tower at the Imperial Airport and another at a local hospital. All hospitals remained otherwise functional with only minor damage. Students were not in class at the time of the quake. Schools remained closed the following day to assess damage. It was all non-structural -- estimated at $345,000, "County-wide". Telephone and telegraph facilities were undamaged, but became inoperative due to overload of attempted calls for up to 18 hours in certain areas. This seriously interfered with emergency analysis and response. Local radio and television (including designated Emergency Broadcast Station) were off the air for about an hour. Total loss was estimated at $30,000,000.

<u>1981 April 27</u>. Westmorland. Magnitude 5.6 Intensity VII. There was more damage to Westmorland than resulted from the October 1979 quake. Several commercial buildings and 16 homes were substantially damaged. The water tower, and the water and sewage treatment plants received $500,000 damage. A quarter mile of the concrete lined Vail Canal was broken up. An eight inch crack opened in Lack Road. There were no injuries, nor significant damage reported elsewhere in the valley.

The swarm of thirty quakes (seven between 3.0 and 4.1) occurred over a 12 hour period three days before the main quake. More than three dozen quakes (over 3.0) occurred in the 24 hours afterwards.

This quake apparently ruptured underground gasoline storage tanks, which was revealed months later with fumes and seepage into surface waters.

<u>1985 May 8</u>. An earthquake measuring 5.2 on the Richter Scale, rocked a large uninhabited area of the Mexican desert 65 miles southwest of Calexico, but there were no reports of damage or injuries, authorities said.

The quake was followed by a series of aftershocks, including one that registered 4.3 on the Richter Scale, according to a spokesman for the California Institute of Technology at Pasadena.

1986 July 8. A quake struck 12 miles northwest of Palm Springs measuring 5.9 on the Richter Scale of ground motion. It did an estimated $5.75 million damage and injured 40 people. Numerous aftershocks, some measuring as high as 4.0 on the Richter scale, have jostled the area since then.

1986 July 13. A 5.3 earthquake epicentered 28 miles southwest of Oceanside in the Pacific Ocean. The quake was felt as far away as Yuma, AZ, 160 miles east of San Diego, but caused no reported damage or injuries in Imperial Valley.

1987 February 6. A strong earthquake shattered windows and disrupted power in Mexicali and briefly interrupted phone service in the Imperial Valley but there were no reported injuries, authorities said. The trembler registered 5.6 on the Richter Scale and was centered 19 miles southeast of Mexicali according to a spokesman of Caltech in Pasadena.

The quake was felt as far east as Yuma, about 60 miles from the epicenter and as far west as San Diego.

1987 November 23-24. Two strong earthquakes, which registered 6.0 and 6.3 on the Richter Scale, caused widespread damage, but few injuries were reported. The Calexico area was apparently the hardest hit by the trembler, which was centered near Westmorland.

Two bridges, on Forrester Road over the New River and on Worthington Road over the New River were damaged according to the County Public Works Department. The California Highway Patrol also reported that Keystone Road between Forrester and Highway 86 is closed because of bridge damage.

1988 January 25. A large earthquake struck Baja California, Mexico, shaking some Californians awake but triggering no immediate damage reports either north or south of the border, officials said.

The quake registered 5.3 on the Richter Scale was centered in a sparsely populated area about 45 miles east of the resort city of Ensenada according to a spokesman of the California Institute of Technology in Pasadena. The U.S. Geological Survey in Golden, Colorado, measured the quake at 5.0. There were no reports of damage in Imperial County.

ENDNOTES

1. Robert Iacopi, *Earthquake Country*, (California:Menlo Park, Lane Books, 1976):58-60.

2. Matthews H. William, *Geology Made Simple*, (New York:Doubleday & Company, Inc., 1982):78.

3. The World Book Encyclopedia, 1988 Edition, *Flash Flood*, (Chicago:World Book Inc., 1987 F Volume 7):237.

4. Office of Emergency Services Imperial County, *Imperial County Emergency Plan*, (June 1988):Appendix 1-3, 57.

5. Federal Emergency Agency, *Flood Insurance Study Imperial County, California Unincorporated Areas*, (September 15, 1983):4.

6. Ibid. p. 4.

7. Ibid. p. 5.

APPENDIX B

STORAGE SITES, HANDLERS, AND VENDORS OF HAZARDOUS MATERIALS AND WASTE

This report contains a summary of the largest concentrations of hazardous material and the obvious sources of massive leaks or spills in the County of Imperial. Space requirements of this document preclude the listing of every potential source of hazardous material and waste. This type of detailed information may be obtained by contacting the County of Imperial Department of Health Services.

1. Santa Fe Pacific Pipe Line Tank Farm

The Santa Fe Pacific Pipe Line Tank Farm is located at Aten Road and the Southern Pacific Railroad junction in the southeast quadrant of the City of Imperial. This facility is a component of the Santa Fe Pacific Pipe Line network that delivers gasoline, diesel, and jet fuel to Southern California and Arizona. The tank farm contains 16 storage tanks, in varying sizes, with a total storage capacity of approximately ten million gallons.

2. Naval Air Facility (El Centro)

The Naval Air Facility (El Centro) is serviced by a four-inch fuel line directly from the Santa Fe Pacific Pipe Line Tank Farm. Safety devices include manual and automatic shutoff valves, as well as pressure regulators. The facility also stores one million gallons of fuel, which is predominantly jet fuel, in underground tanks. Munitions storage is limited to aircraft and small arms training ammunition.

3. ST Services

ST Services is located south of the Santa Fe Pacific Pipe Line Tank Farm and has the capacity to store 70,000 gallons of fuel.

4. Brea Agricultural Service

Brea Agricultural Service is located at 89 East Main Street in the City of Heber and serves as a chemical and fertilizer storage facility.

5. United Agriculture Products

United Agriculture Products is located at 2415 Clark Street in the City of Imperial. This facility handles hazardous wastes, chemicals, insecticides, and pesticides.

6. Puregro Company

The Puregro Company is located at 10th Street and River Drive in the City of Brawley. This facility handles chemicals and fertilizers.

7. Rockwood Chemical Company

Rockwood Chemical Company is located at 47 West Rutherford Road in Brawley. This facility handles chemical and fertilizers.

8. Helena Chemical Products

Helena Chemical Products is located at 101 East Carey Road in the City of Brawley. This facility handles chemicals, fertilizers, insecticides, and pesticides.

9. Wilbur Ellis Company

The Wilbur Ellis Company is located at 45 West Danenberg Road in the community of Heber. This facility handles chemicals, fertilizers, insecticides, and pesticides.

10. Pipelines

There are 89.92 miles of pipeline in Imperial County that transport hazardous material. Pipe sizes vary in size from 12 to 20 inches and the average size is 12 inches. Pipelines are located adjacent to the Southern Pacific tracks from the Arizona border at Yuma to the Niland tank farm, north to the Riverside County Line, and south to the Imperial tank farm. The pipeline system has section fuel control valves.

Source: 1988 Imperial County Emergency Plan